Claims

1. Apparatus for resolving ambiguities in a satellite position navigation system comprising:

a base station located at a known location comprising:

a first satellite receiver capable of receiving navigation satellite signals including carrier signals;

a laser transmitter;

a mobile station comprising:

a second satellite receiver capable of receiving navigation satellite signals including carrier signals;

a photodetection device for receiving laser beams generated by said laser transmitter;

an arithmetic processing unit for processing the laser beams in order to calculate an elevation angle between said laser transmitter on said base station and said mobile station; and

a data processing unit in communication with said first and second satellite receivers for determining the location of said mobile station based at least on part on carrier signals, said processing unit configured to resolve carrier phase ambiguities based at least in part on said elevation angle.

2. The apparatus of claim 1 wherein said data processing unit is configured to resolve carrier phase floating point ambiguities based at least in part on said elevation angle.

3. The apparatus of claim 1 wherein said data processing unit is configured to resolve carrier phase integer ambiguities based at least in part on said elevation angle.

4. The apparatus of claim 1 wherein said laser transmitter comprises a laser device for generating multiple beams having different geometric characteristics.

5. The apparatus of claim 4 wherein said multiple beams are shaped into two or more beams that diverge vertically.

6. The apparatus of claim 5 wherein said arithmetic processing unit for processing the laser beams computes a control signal from time delay between detections of the two or more beams by said photodetection device.

7. The apparatus of claim 1 wherein said data processing unit resolves carrier phase ambiguities as part of a repeated iterative procedure.

8. The apparatus of claim 1 wherein said arithmetic processing unit or said data processing unit calculates a geometric cone having a vertex at said laser transmitter wherein a reference point location for said mobile unit is estimated to be on the surface of said cone.

9. The apparatus of claim 1 wherein said data processing unit estimates first a floating point ambiguity, and then uses said estimated floating point ambiguity at least in part for estimating an integer ambiguity.

10. A method for resolving ambiguities during position determination of a mobile unit in a satellite navigation system comprising the steps of:

receiving a laser beam generated by a laser transmitter at a known location;

calculating an elevation angle between said mobile unit and said laser transmitter; and

resolving ambiguities in carrier waves received by the mobile unit based at least in part on geometric constraint generated from said elevation angle.

11. The method of claim10 wherein said laser beam is N shaped.

12. The method of claim 10 wherein said laser beam comprises two or more fan-shaped beams that diverge vertically.

13. The method of claim 10 wherein said ambiguities are carrier phase integer ambiguities.

14. The method of claim 10 wherein said ambiguities are carrier phase floating point ambiguities.

15. The method of claim 10 wherein said step of resolving comprises the steps of:

generating a geometric cone having a vertex at said laser transmitter wherein a reference point location for said mobile unit is estimated to be on the surface of said cone.

16. The method of claim 10 further comprising the steps of generating multiple laser beams from the laser transmitter, said beams respectively having different characteristics taken from the following: different frequencies, different polarizations, different wavelengths, different geometric forms, different intensities.

17. Apparatus for resolving ambiguities in a satellite position navigation system having a base station at a known location capable of receiving navigation satellite signals, and also having a laser transmitter, said apparatus comprising:

a mobile station;

a satellite receiver on said mobile station;

an optical sensor on said mobile station capable of receiving laser beams generated from the laser transmitter;

processor means for analyzing the laser beams to calculate an elevation angle between said mobile station and the base station, and for resolving location ambiguities based at least in part on said elevation angle.

18. The apparatus of claim 17 wherein said processor means estimates phase integer ambiguities and floating point ambiguities based at least in part on said elevation angle.

19. The apparatus of claim 17 wherein said processor means estimates phase integer ambiguities as part of an initialization process.

20. The apparatus of claim 17 wherein said mobile station is associated with a construction machine.

21. The apparatus of claim 17 wherein said processor means calculates a geometric cone having a vertex at the laser transmitter wherein a reference point location for said mobile unit is estimated to be on the surface of said cone.

22. A method for resolving ambiguities during position determination of a mobile unit having an optical sensor to receive multiple laser beams and having an antenna to receive navigation satellite signals, comprising:

processing the satellite signals received by the antenna of the mobile unit in order to detect cycle and phase parameters;

analyzing the laser beams received by the optical sensor of the mobile unit in order to calculate an elevation angle between the mobile unit and a base station located at a known location; and

resolving ambiguities in an estimated location of the mobile unit based on calculations incorporating the elevation angle.

23. The method of claim 22 which further comprises resolving integer cycle ambiguities based in part on said elevation angle.

24. The method of claim 22 which further comprises resolving floating point ambiguities based in part on said elevation angle.

25. The method of claim 22 which further comprises resolving ambiguities during an initialization process.

26. The method of claim 22 which further comprises calculating a geometric cone based on the elevation angle wherein a reference point location for said mobile unit is estimated to be on the surface of said cone.

27. A computer readable medium storing computer program instructions which are executable on a computer processor for resolving ambiguities during position determination of a mobile unit having an optical sensor to receive multiple laser beams and having an antenna to receive navigation satellite signals, said computer program instructions defining the following steps:

processing the satellite signals received by the antenna of the mobile unit in order to detect cycle and phase parameters;

analyzing the laser beams received by the optical sensor of the mobile unit in order to calculate an elevation angle between the mobile unit and a base station located at a known location; and

resolving both floating point and integer carrier ambiguities using geometric constraint based on calculations incorporating the elevation angle.

28. The computer readable medium of claim 27 which further includes program instructions for calculating a geometric cone based on the elevation angle wherein a reference point location for said mobile unit is estimated to be on the surface of said cone.

29. The computer readable medium of claim 27 which further includes program instructions for first estimating floating point ambiguities, and then using said estimated floating point ambiguities at least in part for estimating integer ambiguities.